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(54) DIGITAL UP-CONVERTER

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a digital up-converter which transmits a broadband signal and is realized by hardware with a simple configuration concerning a method for constituting the digital up-converter to be the configuration element of software radio equipment.
SOLUTION: The digital up-converter is constituted by providing a band limit filter means for limiting a band with respect to an inputted signal, a numerical value control oscillating means for generating a symbol timing signal based on a set value, an interpolation filter means for adopting the output of the band limit filter means as an input and converting the symbol rate based on the timing signal which is generated by the numerical control oscillating means and an unnecessary higher harmonic (alias) restricting filter means for receiving the output of the interpolation filter means.

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CLAIMS

[Claim(s)]

[Claim 1] The digital up converter which carries out [providing a band limit filter means band-limit to the inputted signal, a numerical-control oscillation means generate a symbol timing signal based on the set-up value, an interpolation filter means perform symbol rate conversion based on the timing signal which considered the output of said band limit filter means as an input, and was generated by said numerical-control oscillation means, and the filter means for unnecessary higher-harmonic-wave (alias) oppression that consider the output of this interpolation filter means as an input, and] as the description.

[Claim 2] The digital up converter according to claim 1 which compensates the loss in a passband by weaving beforehand the damping property of the filter means for unnecessary higher-harmonic oppression into the property of a band limit filter means as a reverse property.

[Claim 3] The digital up converter according to claim 1 constituted with the adder which applies and outputs the value currently held in the filter means for unnecessary higher-harmonic-wave oppression at the register holding the value of an input signal, and the value and said register of an input signal.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the modulation technique of a walkie-

talkie, and the construction of a digital up converter which serves as a component of the software walkie-talkie which can be changed flexibly in a band (a frequency, bandwidth) etc. by modification of the control software.

[0002]

[Description of the Prior Art] With a software walkie-talkie, each function of the walkie-talkie which consisted of hardware conventionally in many cases is realized as much as possible by DIJIIRU signal processing. It is the technique realized as data for pro GURAMINDA [software which operates on general-purpose digital-signal-processing devices, such as CPU (CentralProcessing Unit) and DSP (Digital Signal Processor), or FPGA (FieldProgrammable Gate Array)].

[0003] If this technique is used, it will become possible to change flexibly the operating frequency conventionally considered as immobilization, the operational parameter of walkie-talkies, such as a modulation technique, etc. If its attention is paid to a transmitting side, in order to realize a software walkie-talkie, the signal-processing capacity required of the processor which performs signal processing is proportional to the working speed of a D/A converter.

[0004] Therefore, even if the signal itself to process is a narrow-band, to perform signal processing of IF frequency or RF frequency, it is necessary to use a processor with a very high throughput. A digital up converter is one of the components for realizing a software walkie-talkie, and has functions, such as a band limit, conversion of a symbol rate, and frequency conversion.

[0005] By using a digital up converter, with a transmitting symbol, since a processor not only can perform signal processing, but can make the output data rate of a processor low using the clock of an asynchronous high speed, it becomes possible [reducing the demand throughput to a processor].

[0006] The example of a configuration of the conventional digital up converter is shown in drawing 10 . The digital up converter of this example of a configuration consists of frequency converters which consist of the band limit filter means 11 and a numerical-control oscillation means 13 (NCO ;Numerical ControlledOscillator) to generate a symbol timing signal, and an interpolation filter means 12 to perform conversion of a symbol rate.

[0007] The inputted transmit data train is band-limited by the band limit filter means 11. This band limit filter means 11 is realized as an FIR (Finite Impulse Response) filter in many cases. On the other hand, the numerical-control oscillation means 13 generates the timing signal of a symbol rate. Based on this timing signal, the interpolation filter means 12 changes a symbol rate to the output of the band limit filter means 11.

[0008] The approach using an FIR filter as a configuration of the interpolation filter means 12 and the approach based on an interpolation polynomial are learned. The approach using an FIR filter is stated to reference 1 (-.P.Vaidyanathan, Multirate Systems and Filter Banks ["Multirate Systems and Filter Banks"], Prentice Hall, and

1993.) at the detail.

[0009] By the approach using an FIR filter, it decomposes into two or more filters which generate the output from which a phase differs, and a desired signal is acquired by switching using the migration information which can obtain the output from each filter from NCO. As an example of a configuration of the interpolation filter using an FIR filter, the configuration of the interpolation filter which performs 4 times as many interpolation as this to drawing 2 is illustrated.

[0010] When the tap multiplier of the FIR filter which becomes a radical is set to hi (i= 0 to N−1), transfer function [of an FIR filter] R (z) is expressed with "a-one number." The frequency characteristics of an interpolation filter are determined by R (z).

[0011]

[Equation 1]

[0012] R (z) is the transfer function R0 of each filter which could decompose like "a-two number" and was disassembled. (z) and R1 (z) and R2 (z) and R3 (z) becomes "number 3"- "a-six number."

[0013]

[Equation 2]

[0014]

[Equation 3]

[0015]

[Equation 4]

[0016]

[Equation 5]

[0017]

[Equation 6]

[0018] NCO outputs symbol timing and phase shift mu at the symbol tie MINDA event. Four filter outputs are changed with the magnitude (0-2pi [rad]) of the phase shift mu. That is, output y (k) is given by "the-seven number."

[0019]

[Equation 7]

[0020] On the other hand, the approach based on said interpolation polynomial is stated to reference 2 (: Lars Erup, FloydM.Gardner, Robert A.Harris, Implementation and Performance ["Interpolation in Digital Modems-Part II:Implementation and Performance"], IEEE Trans.on Commun.Vol.41, No.6, June1993.) in detail.

[0021] By this approach, the symbol which adjoined in time [the signal inputted based on the topology from NCO] was interpolated by the interpolation polynomial, and the desired signal has been acquired. The configuration of the interpolation filter which used the 3rd interpolation polynomial for drawing 3 is shown. Phase shift mu at the symbol timing and symbol tie MINDA event (0-1.0 [symbol]) is inputted from NCO like the case of a configuration with an FIR filter. Interpolation filter output y (k) is expressed with "a-eight number" and "a-nine number" as 3rd function of mu.

[0022]

[Equation 8]

[0023]

[Equation 9]

[0024] Here, n is the interpolation order of a polynomial, M is the die length of the impulse response of an interpolation filter, and it is n= 3 and M= 3 in the example of

drawing 3 . L1 (i) is the multiplier of a Lagrange polynomial and is given with "a table 1."

[0025]

[A table 1]

[0026] Generally, it is L1. Since each value of (i) is expressed with an easy fraction, if the degree of a polynomial is chosen well, the multiplication in "a-nine number" can be simplified by a bit shift etc., substantially, there will be few required multipliers and it will end. The above thing shows having the description that the interpolation filter by the interpolation polynomial has a simple configuration compared with an interpolation filter with an FIR filter. On the other hand, the latter has the property of having ripple-like gain out of a passband.

[0027]

[Problem(s) to be Solved by the Invention] An adverse effect will be brought to the channel which the image component of a signal adjoins as an unnecessary higher harmonic wave (alias) if it has gain outside the passband of the signal which the frequency characteristics of an interpolation filter tend to transmit. In the interpolation filter with an FIR filter, for realizing a good alias oppression property, the number of taps needed to be made [many], therefore circuit magnitude became large, and the technical problem that buildup of processing delay was caused occurred.

[0028] On the other hand, by the approach based on an interpolation polynomial, although the configuration is simple, since it had ripple-like gain outside a passband, it had the technical problem that a high alias oppression property was unrealizable. This invention aims at offering a digital up converter realizable [that a broadband signal can be transmitted] by the hardware of a brief configuration.

[0029]

[Means for Solving the Problem] According to this invention, an above-mentioned technical problem is solved by the means indicated to said claim. Namely, a band limit filter means to band-limit to the signal into which invention of claim 1 was inputted, A numerical-control oscillation means to generate a symbol timing signal based on the set-up value, An interpolation filter means to perform symbol rate conversion based on the timing signal which considered the output of said band limit filter means as the input, and was generated by said numerical-control oscillation means, It is a digital up

converter possessing the filter means for unnecessary higher-harmonic-wave (alias) oppression which considers the output of this interpolation filter means as an input.
[0030] In a digital up converter according to claim 1, by weaving beforehand the damping property of the filter means for unnecessary higher-harmonic oppression into the property of a band limit filter means as a reverse property, invention of claim 2 is constituted so that the loss in a passband may be compensated.
[0031] In a digital up converter according to claim 1, the adder which applies and outputs the value currently held in the filter means for unnecessary higher-harmonic-wave oppression at the register holding the value of an input signal, and the value and said register of an input signal constitutes invention of claim 3. 1 bit before being held at this time, for example, a register, the value in front of 2 bits or more and the value of an input signal are outputted from an adder.
[0032] As mentioned above, in this invention, it is characterized by providing the filter means for alias oppression in the latter part of an interpolation filter means. In addition, also from the object of this invention, although it needs to be simply realizable in digital one, since a digital up converter can oppress an alias with the filter of a brief configuration, it can realize the digital up converter equipped with the simple and good alias oppression property according to this invention.
[0033]
[Embodiment of the Invention] Drawing 1 is drawing showing the gestalt of operation by this invention. The FIR filter realized the root roll-off filter of alpha= 0.5 as a band limit filter means 1, and it has the frequency converter which consists of an interpolation filter means 2 by the secondary interpolation polynomial, and a numerical-control oscillation means 3. Said interpolation filter means 2 itself is shown in said reference 2 at the detail.
[0034] With the gestalt of this operation, the 4 times as many signal which carried out the exaggerated sampling as this is used as an input signal. Namely, frequency fproc of a processing clock It is 4 times the symbol rate before the rate conversion by the interpolation filter means 2. Moreover, a symbol rate shall be raised 1.1 times with the interpolation filter means 2. The configuration of this interpolation filter means 2 is shown in drawing 4 , and multiplier [of a polynomial] L (i) is shown in "a table 2", respectively.
[0035]
[A table 2]

[0036] The frequency characteristics of an interpolation filter become like the alternate long and short dash line in drawing 5 . Moreover, in order to clarify the alias oppression property by the interpolation filter, the frequency spectrum (continuous line) of the signal and alias at the time of inputting into drawing 5 a signal (broken line) without the twice as many band limit which carried out the exaggerated sampling (sample rate = symbol rate x2; the worst conditions) as this was written together.
[0037] Each multiplier of this interpolation filter means 2 is 0, **1 / 1, or 3/2, and a bit shift and an adder subtracter can realize multiplication required for "a-nine number". [2 and 1] The output frequency spectrum of the interpolation filter means 2 is shown in drawing 6 . Drawing 6 shows that the alias has occurred out of band with the output of the interpolation filter means 2.
[0038] Although the alias oppression filter means 4 needs to be the filter of a simple configuration, the filter shown in drawing 7 is used for it here. The frequency characteristics of this filter come to be shown in drawing 8 . Although a signal declines a little in a ****** passband to the activity of this alias oppression filter 4, this can be compensated with weaving in that reverse property in case the band limit filter means 1 is designed beforehand.
[0039] The alias oppression filter means 4 shown with the gestalt of this operation can be constituted only from an adder and a register, and is dramatically simple, and high-speed operation is possible for it. The frequency spectrum in the equipment output by the gestalt of this operation at the time of guaranteeing the property in a passband of the alias oppression filter means 4 is shown in drawing 9 . It is possible for this to secure -55dB or more whenever [oppression / of an alias] to a signal component with the gestalt of this operation.
[0040]
[Effect of the Invention] Since it is possible to oppress an alias by adding the filter of a brief configuration to the conventional digital up converter and the same digital up converter of a configuration according to this invention as explained above, there is an advantage which can realize easily the digital up converter simply equipped with the good alias oppression property.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the example of the configuration of the digital up converter by this invention.

[Drawing 2] It is drawing showing the example of the configuration of the interpolation filter using an FIR filter.

[Drawing 3] It is drawing showing the example of the configuration of the interpolation filter using the 3rd interpolation polynomial.

[Drawing 4] It is drawing showing the example of the configuration of the interpolation filter using a secondary interpolation polynomial.

[Drawing 5] It is drawing showing the frequency spectrum of the frequency characteristics of an interpolation filter, a signal, and an alias.

[Drawing 6] It is drawing showing the frequency spectrum of an interpolation filter output.

[Drawing 7] It is drawing showing the example of the configuration of the alias oppression filter in the gestalt of operation of this invention.

[Drawing 8] It is drawing showing the frequency characteristics of the alias oppression filter in the gestalt of operation by this invention.

[Drawing 9] It is drawing showing the overall characteristic in the gestalt of operation by this invention.

[Drawing 10] It is drawing showing the example of the configuration of the conventional digital up converter.

[Description of Notations]

1 11 Band limit filter means

2 12 Interpolation filter means

3 13 Numerical-control oscillation means

4 Alias Oppression Filter Means